Fig 2. Completion digital subtraction angiography showing successful embolization of bilateral renal arteriovenous malformations (AVMs).

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Is Left Renal Vein Ligation Benign? A Novel Method for Maintaining Left Renal Venous Outflow During Extensive Inferior Vena Caval Resection.

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Introduction: Ligation of the left renal vein (LRV) has been felt to be a relatively benign maneuver, with renal venous outflow maintained through existing venous branches. LRV has shown to be of negligible in long-term renal function in the setting of aneurysm repair with dual kidneys; the effect of LRV in the setting of a solitary left kidney, however, is less well described. Case reports, primarily in the urology literature, have described sudden deterioration in renal function with LRV during right nephrectomy, and hence, the consequences of acute LRV might better be described as "unpredictable." This report describes a patient who suffered rapid renal deterioration from left renal vein obstruction secondary to recurrent renal cell carcinoma, underwent extensive inferior vena cava (IVC) resection, and on whom a novel method for intraoperative maintenance of left renal venous drainage during level III vena caval resection was used.

Methods: The patient, a 62-year-old man evaluated for rapidly progressive lower extremity edema, had undergone laparoscopic right nephrectomy 9 years earlier without venous or extrarenal spread. An echocardiogram noted a mass in the IVC, and subsequent magnetic resonance imaging demonstrated a suspected recurrent tumor involving the IVC and extending to the level of the right hepatic vein. Creatinine had concomitantly risen from 1.2 to 2.9 mg/dL during an 8-day period. The left renal vein was patent, with some flow into IVC along with patent left gonadal, adrenal, and lumbar veins. Results of a metastatic survey were negative. The patient was offered IVC resection. Exposure was performed through a right thoracoabdominal incision, with confirmation of tumor extent and absence of metastases. The left renal vein was extensively mobilized, and caval resection and reconstruction from the L3 level to right hepatic vein was planned. A venovenous circuit was created using percutaneously placed cannulas in the right common femoral and right internal jugular veins. With concerns for further compromise of renal function from even temporary renal vein occlusion, a 24F right-angle single-stage venous cannula was placed in the left renal vein, and bypass with left renal vein decompression was instituted using full-heparinization. Potentially curative resection was performed uneventfully, and the IVC was reconstructed using a 24-mm Dacron graft with a 10-mm sidearm left renal graft. Total bypass time was 139 minutes, and urine output during the bypass period was 240 mL.

Results: Excellent urine output was seen throughout the perioperative period, with creatinine returning to value of 1.1 mg/dL by postoperative day 5. The patient was discharged on postoperative day 7. Postoperative venous-phase computed tomography has demonstrated patent IVC and left renal vein interposition grafts.

Conclusions: The effect of LRV with a solitary left kidney is unpredictable; the negligible effects of LRV after aneurysm repair may be more an effect of right kidney compensation rather than a reflection on the benignity of LRV. When planning pararenal vena caval resection and reconstruction, reconstruction of the left renal vein is advisable, and intraoperative renal function can be optimized using the renal vein drainage technique described above.

Author Disclosures: C. S. Kiell: None; **A. R. Barksdale:** None.

Endostaples for Distal Fixation in a Thoracic Endovascular Aortic Aneurysm Repair (TEVAR)

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Introduction: We report the case of 77-year-old woman with an asymptomatic enlarging distal thoracic aortic aneurysm (TAA) treated with endovascular repair using endostaples.

Methods: The patient was a former smoker with a history of hypertension, chronic kidney disease, asthma, and hypothyroidism. Physical examination was significant for a pulsatile mass in the midabdomen. She was followed up with serial computed tomography angiography (CTA) for 5 years. The TAA measured 3.8 cm in 2009, enlarging to 5.5 cm in 2013. CTA revealed a short distal neck ~5 mm proximal to the celiac axis. Therefore, the decision was made to use endostaples for distal fixation.

Results: After informed consent, the patient was taken to the operating room. A 7F sheath was inserted via a right femoral exposure. The left common femoral artery was accessed percutaneously. An aortogram confirmed a short distal neck. The celiac artery was selected with a guidewire, and access was maintained in the hepatic artery with a glide catheter. A Cook Zenith TX2 28-mm × 80-mm endograft (Cook Medical, Bloomington, Ind) was deployed. Four Aptus Heli-FX Thoracic EndoAnchors (Aptus Endosystems Inc, Sunnyvale, Calif) were placed at 2, 4, 8, and 10 o'clock. A completion angiogram showed no endoleak and good filling of the celiac artery. The patient tolerated the procedure well, without any complications. She was discharged the next day, and remained well at the 2-month follow-up. A CTA at the 2-month follow-up confirmed good placement of graft, with no endoleak, and the aneurysm was completely excluded.

Conclusions: There are multiple options for obtaining distal fixation during thoracic endovascular aortic repair. These include coverage of the celiac axis, barbs/hooks on the graft, distal graft visceral uncovered bare-metal stents, fenestrated/scalloped stent grafts, branched endografts, parallel stenting (chimney, snorkel, or periscope), and endoanchors, endostaples, and endoscrews. This case is an example of a distal TAA with difficult anatomy due to a short distal neck treated with endovascular repair using endostaples to ensure distal fixation and reduce the risk of migration. Endostaples can serve as a safe and viable alternative that is minimally invasive for handling short landing zones. Early results with endostaples are promising, but further studies are warranted to evaluate long-term safety and durability. The ANCHOR registry is designed to evaluate patients from multiple sites treated with the Aptus Heli-FX EndoAnchor System and is currently enrolling.

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Current Accepted Hemodynamic Criteria for Critical Limb Ischemia (CLI) Do Not Accurately Stratify Patients at High Risk for Limb Loss

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Introduction: Critical limb ischemia (CLI) has been defined as patients with rest pain or tissue loss who have an ankle pressure (AP) <70 mm Hg or toe pressure (TP) <50 mm Hg. Data suggesting these patients are at high risk for limb loss without successful revascularization are limited. This study was designed to identify limb loss and mortality rates in patients who did not respond to revascularization or who were not revascularized and to determine whether CLI hemodynamic criteria accurately identify patients at high risk for limb loss.

Methods: Between 2008 and 2010, all patients undergoing lower extremity arterial duplex testing at our hospital were identified. Those with an AP <70 mm Hg or TP <50 mm Hg were retrospectively reviewed to determine whether they had symptoms of rest pain or tissue loss qualifying them for analysis in the database. Patients who underwent revascularization and

subsequently had postrevascularization APs or TPs greater than the CLI criteria were removed from the cohort. Demographic factors, wound healing, amputation rates, and mortality were obtained and analyzed in relation to the initial APs and TPs. Outcomes were measured using Kaplan-Meier life-table analysis and Cox proportional hazards models.

Results: CLI criteria were identified in 443 limbs of 381 patients. After revascularization, 98 limbs with AP or TP, or both, improved to >70 mm Hg and 50 mm Hg were removed from the study cohort. In 45 limbs, patients did not respond to the intial revascularization and their APs or TPs, or both, remained within CLI criteria. These limbs remained in the patient cohort, yielding a final group of 296 patients and 345 limbs. Mean follow-up time was 2.0 years. In the entire patient cohort, limb loss occurred in 24% at 1 year and in 31% at 3 years. Mortality was 32% at 1 year and 56% at 3 years. Amputation-free survival was 54% at 1 year and 28% at 3 years. Lower TPs were associated with a significantly higher incidence of amputation. Among the 85 with an initial TP ≤10 mm Hg, limb loss occurred in 46% at 1 year and in 60% at 3 years. This limb loss was significantly greater than limb loss of 18% at 3 years among the 115 with a TP of 31 to 50 mm Hg ($P < .001$, Fig). Amputation-free survival in patients with a TP ≤10 mm Hg was 8% at 3 years.

Conclusions: CLI is associated with a high mortality, but not all patients with currently defined hemodynamic criteria for CLI are at high risk of limb loss. Patients with a TP between 31 and 50 mm Hg (41% of the cohort) and not receiving revascularization or not responding hemodynamically to revascularization experienced a low risk of limb loss. We recommend revising the hemodynamic criteria for CLI to better identify patients at high risk for limb loss who require intervention to improve outcomes.

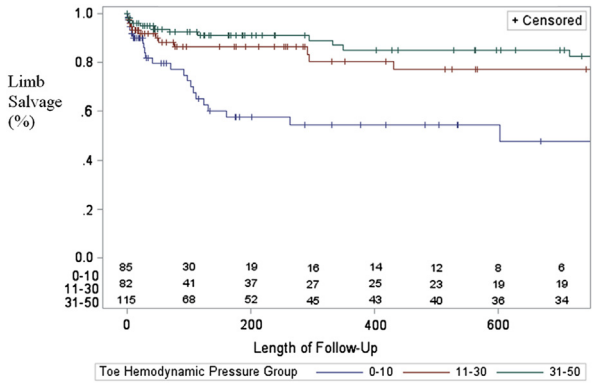

Fig. Limp salvage by toe hemodynamic pressure groups.

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Primary Stent Placement Improves Patency After Endovascular Treatment of Hepatic Artery Stenosis Following Liver Transplantation

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Introduction: Significant hepatic artery stenosis (HAS) after orthotopic liver transplantation (OLT) can lead to thrombosis with subsequent liver failure in 30% of patients. Although operative intervention or retransplantation has been the traditional solution, endovascular therapy has emerged as a less invasive treatment strategy. Prior smaller studies have been conflicting in the relative efficacy of percutaneous transluminal angioplasty (PTA) vs primary stent placement for HAS.

Methods: This was a single-center retrospective review of all endovascular interventions for HAS after OLT during a 54-month period (August 2009-December 2013). Patients with ultrasound evidence of severe HAS (peak systolic velocity >400 cm/s, resistive index of <0.5, tardus parvus spectral abnormalities) underwent endovascular treatment with primary stent placement or PTA. Outcomes calculated were technical success, primary and primary assisted patency rates, reinterventions, and complications.

Results: Sixty-two interventions for HAS were performed in 42 patients with a mean follow-up of 19.1 ± 15.2 months. During the study period, the rate of treated HAS was 6.4% (42 of 654). Primary technical success was achieved in 95% (59 of 62) of cases. Initial treatment was with PTA alone (n = 16) or primary stent (n = 26). Primary patency rates after initial stent placement were 91%, 81.3%, 77%, and 77% at 1, 6, 12, and 24 months, respectively, and significantly better ($P = .01$) compared with 68.8%, 57.1%, 44% for initial PTA (Fig). There were 20 reinterventions in 14 patients (eight stents, six PTAs) for recurrent HAS. The time to initial reintervention in patients with PTA alone vs initial stent was 51 and 105.8 days, respectively. Stent placement was required in 75% of reinterventions, of which five drug-eluting stents were placed. Overall Kaplan-Meier primary patency rates were 82%, 70%, 63%, and 50% at 1, 6, 12, and 24 months, respectively. Overall primary-assisted patency was 96% at 12 months and 93% at 24 months. Major complications were one arterial rupture treated endovascularly and two hepatic artery dissections. Long-term risk of HAT in the entire patient cohort was 4.8%.

Conclusions: In this series, which represents the largest reported cohort of endovascular interventions for HAS to date, we demonstrate that HAS after OLT can be treated endovascularly with high initial technical success and excellent primary assisted patency. Initial stent placement significantly decreased the need for reintervention. Avoidance of HAT is possible in >95% of patients with endovascular treatment and close follow-up.

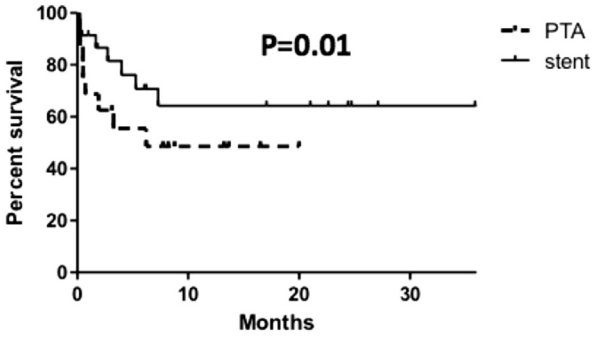

Fig. Primary patency: Percutaneous transluminal angioplasty (*PTA*) vs stent.

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Validated Prediction of Groin Infection After Revascularization Procedures

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Introduction: Groin wound infection is a costly and morbid event after lower extremity revascularization. To date, a comprehensive and validated method for identifying patients who are at greatest risk for this complication, and who might therefore benefit from prophylactic muscle flap coverage of their initial groin incision, has yet to be developed.

Methods: Our retrospective analysis included all patients at a single institution who underwent lower extremity revascularization in which a groin incision was used from 2009 through 2012. Patients were randomly divided into two groups matched for operative year and surgeon: a pilot group, which was used to develop a predictive model for our primary outcome, and a validation group, which was used to test that model. The primary outcome for our analysis was groin wound infection requiring operative intervention. Potential predictor variables included patient age, sex, year of operation, previous groin incision, use of thrombolytic agents, concomitant amputation, body mass index, smoking status, diabetes mellitus, end-stage renal disease, malnutrition, preoperative wound, type of conduit, level of distal target vessel, and emergency status of the index operation. Best-fit model selection methods were used to evaluate all possible combinations, interactions, and transformation of potential predictor variables from the pilot patient group. The resulting model with the lowest Akaike information criterion was selected for testing using the validation patient group. A user-friendly computer program was developed that uses this model to predict an individual patient's risk of operative groin wound infection.

Results: The study included 284 patients, 141 in the pilot group and 144 in the validation group, who underwent lower extremity revascularization procedures. Seventeen patients (12.1%) from the pilot group developed groin incision infection that required operation. The predictive model that